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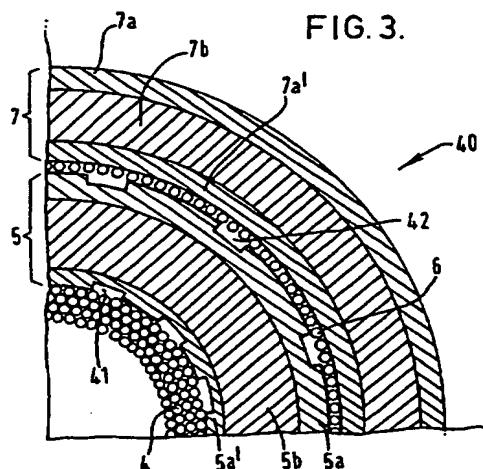
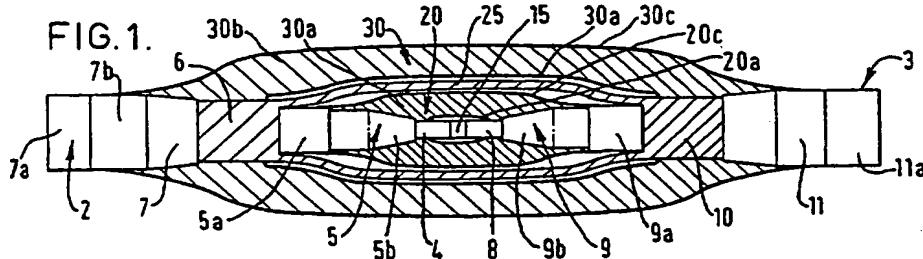
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(54) Abstract Title

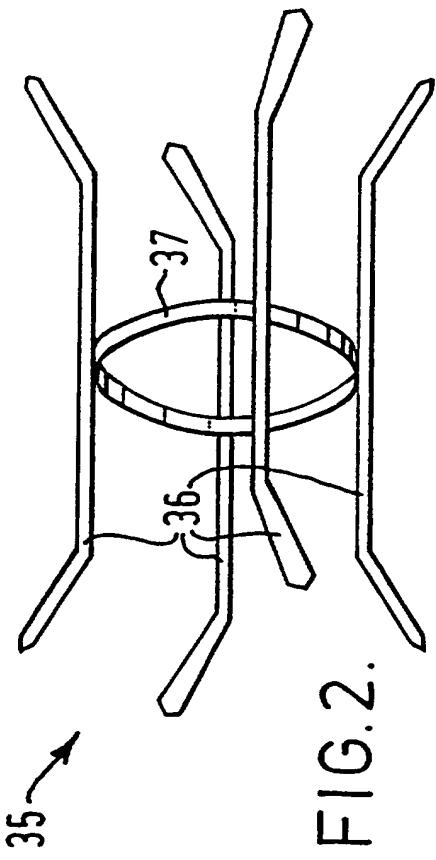
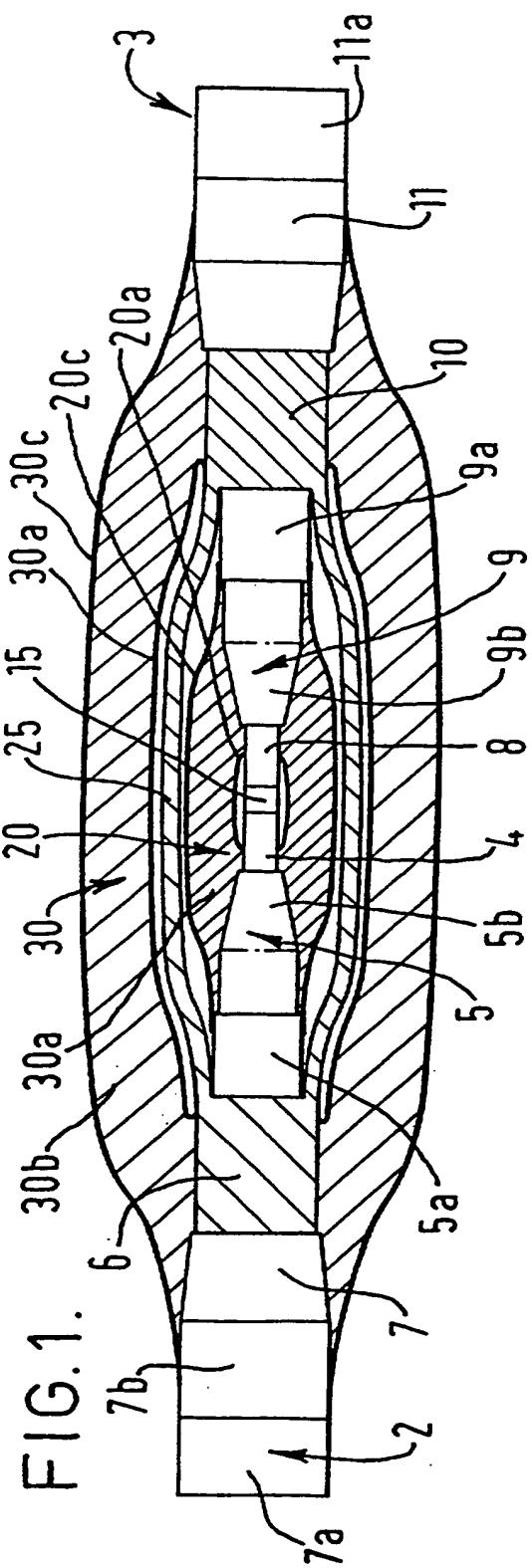
Coaxial power cable joint

(57) Two coaxial power cables 2,3 have inner conductive cores 4,8 and outer conductive cores 6,10. Preferably the cores are superconductors and are cooled. The cables 2,3 have insulation layers 5,9,7,11 which surround each core and comprise solid insulating material 5b,7b sandwiched between solid semiconducting material 5a,5a',7a,7a'. When the cables 2,3 are to be joined the insulation is stripped back to expose the cores 4,6,8,10. The cores are then joined with separate joints 15,25. The two joints 15,25 are insulated from each other, and this is preferably by similar layers of insulation 20,30 to those that surround the cables 2,3. The insulation 20,30 can be applied as a heat-shrunk sleeve or tape.



At least one drawing originally filed was informal and the print reproduced here is taken from a later filed formal copy.

GB 2 350 495 A



2 / 2

### FIG. 3.

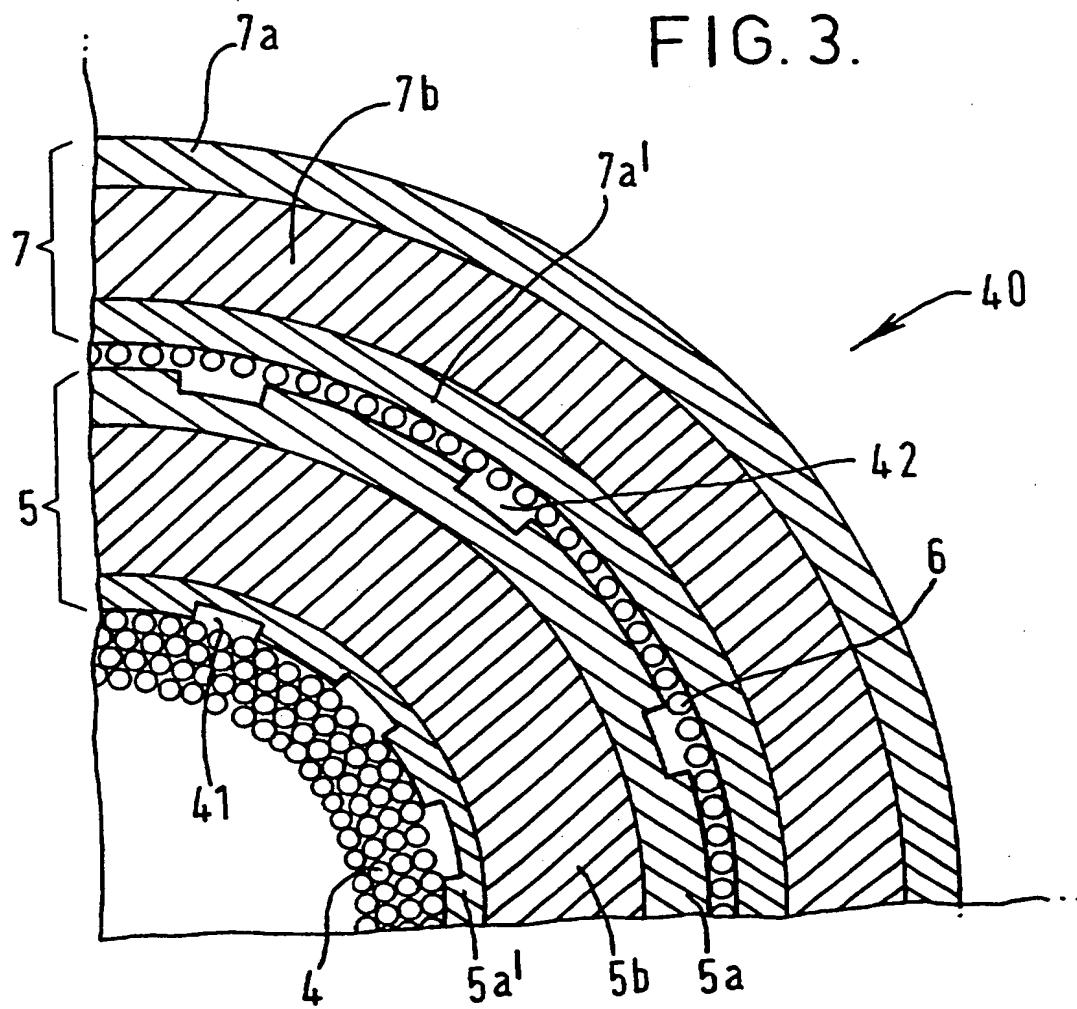
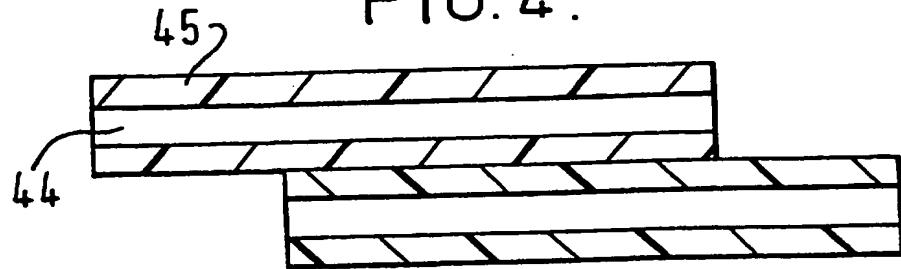


FIG. 4.



POWER CABLE JOINT ASSEMBLIESTechnical Field

This invention relates to a power cable joint assembly and to a power induction device including at least 5 one cable joint assembly for connecting together two high voltage cables, e.g. operating at up to 800 kV or higher. The invention is applicable to the joining together of uncooled cables or the joining together of cables at least one of which is cooled in use to a low temperature to 10 improve its electrical conductivity, e.g. a superconducting power cable, preferably a so-called high-temperature (high- $T_c$ ) superconducting (HTS) power cable. A power induction device incorporating a cable joint assembly may comprise, for example, a fault current limiter, a transformer, motor, 15 generator or magnetic energy storage device, such as a superconducting magnetic energy storage (SMES) device. The invention also relates to a method of joining together two high voltage or power cables in, or for use in, a power induction device.

20 State of the Art

In a power induction device, the joining together of high voltage power cables, each having an electrical conductor surrounded by electrical insulation is well known. In such a known cable joint assembly, it is conventional for 25 the electrical insulation to be stripped from end regions of the cables to be joined to reveal the underlying electrical conductors. These electrical conductors are then joined, e.g. soldered, welded or mechanically joined, together and the joined together conductors are surrounded at the joint 30 by polymeric material. An example of such a known joint assembly in which the polymeric material comprises a cross-linked polymer tape is disclosed in US-A-4,084,307. However in other known joints the polymeric material may be in the form of a prefabricated joint, an elastomer taped joint

which is self-amalgamating or an extruded or taped layer of the polymeric material which is cross-linked in situ.

- US-A-4,084,307 relates to the connection of cables intended to operate at normal room or ambient temperatures.
- 5 The joining together of two cooled, e.g. superconducting, cables is more complex than the joining together of conventional, non-cooled cables since it requires the joining together of conduits for cryogenic cooling fluids, the joining together of conducting means, e.g.
- 10 superconducting tapes or threads, and the provision of electrical insulation around the joint. Conventionally it has been necessary to ensure that the electrical insulation surrounding the joint is not subjected to a large thermal gradient which may result in mechanical stress and
- 15 degradation of the insulation. In practice conventional electrical insulation is thermally insulated externally so that it is close to the temperature of the inner cooled conductors and/or is thermally insulated inwardly between itself and the inner conductors so that it is not cooled
- 20 close to cryogenic temperatures.

#### Summary of the Invention

An aim of the present invention is to provide an improved cable joint assembly for joining together two high voltage cables each having coaxially arranged conducting means with surrounding insulation. It is also an aim of the invention to provide an improved method of joining together 25 two such cables in a power induction device.

According to one aspect of the present invention there is provided a cable joint assembly comprising:

- 30 first and second cables joined end to end, each cable having at least two coaxially arranged electrically conducting means and, positioned around each electrically conducting means of each cable, solid electrically insulating means, each solid

electrically insulating means comprising inner and outer layers of semiconducting material and, between said inner and outer layers, an intermediate layer of electrically insulating material;

5           the solid electrically insulating means being removed from each joined cable end to expose one end of the electrically conducting means of each cable;

10          the said one end of each of the conducting means of one of the cables being joined at a separate joint to a corresponding one end of each of the conducting means of the other cable; and

additional electrical insulation means surrounding each pair of joined together conducting means at said joints.

15          In this specification the term "semiconducting material" means a substance which has a considerably lower conductivity than an electric conductor but which does not have such a low conductivity that it is an electric insulator. Suitably, but not exclusively, the semiconducting material will have a resistivity of from 1 to  $10^5$  ohm·cm, preferably from 10 to 500 ohm·cm and most preferably from 10 to 100 ohm·cm, typically about 20 ohm·cm.

25          Preferably each additional electrical insulation means comprises an inner first layer of semiconducting material, an outer second layer of semiconducting material and, between said first and second layers, an intermediate third layer of electrically insulating material. There should be no gaps between the adjacent layers. The first layer can be spaced from the underlying conducting means provided that there is electrical contact therebetween along their lengths, e.g. at spaced intervals along their lengths.

The first, second and third layers of each additional electrical insulation means may comprise prefabricated

sleeves positioned over, extrusion layers extruded around, or tapes wrapped around, each joint. For the semiconducting first and second layers, each extrusion layer or tape will incorporate semiconducting material. Prefabricated sleeves 5 may be provided for each of the layers of the additional electrical insulation means although a preferred design is to make a preformed, integral sleeve including all the various layers of the electrical insulation means. Appropriate semiconducting material will be incorporated in 10 the separate layer sleeves forming the first and second layers and in the appropriate layered regions of an integrally layered sleeve. The use of sleeves is particularly preferred since the thicknesses of the layers are more consistent and the contact between layers and 15 conducting means is more consistent. A tubular sleeve (either a preformed integral sleeve or a "single layer" sleeve) may be made from elastic material (such as ethylene propylene rubber (EPR) or silicone rubber) which is made with a somewhat undersized diameter. The sleeve in use is 20 stretched or expanded over the joint before it is allowed to elastically relax when in position on the joint. Alternatively the sleeve may be shrunk onto the joint by the application of heat.

Wound tape of suitable insulating or semiconducting 25 material is suitably tightly wound in position to the desired layer thickness. If appropriate materials are incorporated in the tape, the wound tape may be vulcanised. Vulcanising is achieved by incorporating ingredients in the tape so that vulcanisation occurs in the joint assembly 30 after jointing at room temperature. Alternatively, a layer may be heated to vulcanise it. A suitable tape can also be made in two-part form with a removable backing tape and a layer of elastic or polymeric semiconducting or insulating material.

35 Wound tapes, e.g. of polyethylene, may be consolidated by heating which causes them to contract around the joint.

A cable joint assembly according to the invention may incorporate a combination of wrapped and prefabricated layers.

Examples of plastics materials for the electrical insulation means comprise a fluoropolymer, e.g. TEFLON (Trade Mark), low or high density polyethylene (LDPE or HDPE), polypropylene (PP), polybutylene (PB), polymethylpentene (PMP), ethylene (ethyl) acrylate polymer, cross-linked (or cross-linkable) materials, such as cross-linked polyethylene (XLPE), or rubber insulation, such as ethylene propylene rubber (EPR) or silicone rubber.

The first and second cables may be cooled and, in particular, may comprise superconducting electrical conducting means. In the case where the or each conducting means comprises superconducting means, the superconducting means may comprise elongate superconducting material, preferably HTS material, e.g. in tape or thread form, helically wound around a support tube. If the conducting means each comprise superconducting means, the support tubes are suitably mechanically joined, e.g. welded, together at the joint and electrical connection is made between end regions of the elongate superconducting materials of the first and second superconducting means. The helically wound HTS material is suitably cooled to below the critical temperature  $T_c$  of the HTS by cooling fluid passing through the support tubes.

There are many different types of HTS material which are normally ceramic materials. A typical example of elongate HTS material in thread or tape form comprises silver-sheathed BSCCO-2212 or BSCCO-2223 (where the numerals indicate the number of atoms of each element in the [Bi, Pb], Sr, Ca, Cu, Ox molecule). BSCCO threads or tapes are made by encasing fine filaments of the oxide superconductor in a silver or silver oxide matrix by a powder-in-tube (PIT) draw, roll, sinter and roll process. Alternatively the

threads or tapes may be formed by a surface coating process. In either case the oxide is melted and resolidified as a final process step. Other HTS threads or tapes, such as TiBaCaCuO (TBCCO-1223) and YBaCuO (YBCO-123) have been made 5 by various surface coating or surface deposition techniques. Two HTS threads, each having an outer electrically conductive, e.g. metallic (silver), layer, can be joined together by joining the conductive layers of the two threads. For example end portions of two such HTS threads 10 can be overlapped and the silver outer layers can be soldered together. In this case, the silver layers act as "bridges" connecting the HTS material together.

Each of said intermediate layers of said solid electrically insulating means preferably comprises polymeric material such as, for example, low density polyethylene (LDPE), high density polyethylene (HDPE), polypropylene (PP), cross-linked materials such as cross-linked polyethylene (XLPE) or rubber insulation such as ethylene propylene rubber (EPR) or silicone rubber. The semiconducting inner and outer layers of said solid electrically insulating means are formed of similar polymeric materials but with highly electrically conductive particles, e.g. of carbon black or metal, embedded therein. Typical examples of materials for the insulating and semiconducting layers are disclosed in US-A-4,785,138.

According to another aspect of the present invention there is provided a method of joining together end to end first and second cables, each cable having at least two coaxially arranged electrically conducting means and, positioned around each electrically conducting means of each cable, solid electrically insulating means, each solid electrically insulating means comprising inner and outer layers of semiconducting material and, between said inner and outer layers, an intermediate layer of electrically insulating material, the method comprising joining exposed ends of the conducting means of one of the cables to corresponding exposed ends of the conducting means of the

other cable and surrounding each pair of joined together conducting means with additional electrical insulation means.

Preferably each additional electrical insulation means comprises an inner layer of semiconducting material, a surrounding layer of electrically insulating material and a surrounding outer layer of semiconducting material. These are conveniently applied successively but may be applied as a preformed or prefabricated, integral layer sleeve.

10 Brief Description of the Drawings

Embodiments of the invention will now be described, by way of example only, with particular reference to the accompanying drawing, in which:

15 Figure 1 is a schematic sectional view of a power cable joint assembly according to the invention;

Figure 2 is a schematic perspective view, on an enlarged scale, of a contact device for use in another embodiment of power cable joint assembly according to the invention;

20 Figure 3 is a schematic sectional view through part of another embodiment of power cable joint assembly according to the invention; and

Figure 4 is a schematic sectional view illustrating the joining together of two overlapping superconducting wires.

25 Figure 1 shows a joint assembly, generally designated by the reference numeral 1, for a power induction device (not shown) in which first and second cables 2 and 3 are joined together. The first cable 2 comprises elongate inner conducting means 4, surrounding inner electrical insulation 30 5, outer conducting means 6 coaxial with the inner conducting means 4 and surrounding outer electrical

insulation 7. The second cable 3 comprises elongate inner conducting means 8, surrounding inner electrical insulation 9, outer conducting means 10 coaxial with the inner conducting means 8 and surrounding outer electrical insulation 11.

Each "band" of electrical insulation 5, 7, 9 and 11 has solid inner and outer layers 5a, 7a, 9a and 11a of semiconducting material and a solid intermediate layer of insulating material 5b, 7b, 9b and 11b. By way of example only, each solid intermediate layer 5b, 7b, 9b and 11b may comprise cross-linked polyethylene (XLPE). Alternatively, however, the solid intermediate layer may comprise other cross-linked materials or rubber insulation, such as ethylene propylene rubber (EPR) or silicone rubber, or thermoplastic materials such as low density polyethylene (LDPE), high density polyethylene (HDPE), polypropylene (PP), polybutylene (PB), polymethylpentene (PMP) or ethylene (ethyl) acrylate copolymer. The semiconducting material of the inner and outer layers 5a, 7a, 9a and 11a may comprise, for example, a base polymer of similar material to the solid intermediate layers 5b, 7b, 9b and 11b and highly electrically conductive particles, e.g. particles of carbon black or metallic particles, embedded in the base polymer. The volume resistivity, typically about 20 ohm·cm, of these semiconducting layers may be adjusted as required by varying the type and proportion of carbon black added to the base polymer. The following gives an example of the way in which resistivity can be varied using different types and quantities of carbon black.

	<u>Base Polymer</u>	<u>Carbon Black Type</u>	<u>Carbon Black Quantity (%)</u>	<u>Volume Resistivity Ω·cm</u>
5	Ethylene vinyl acetate copolymer/nitrite rubber	EC carbon black	-15	350-400
	-"-	P-carbon black	-37	70-10
	-"-	Extra conducting carbon black, type I	-35	40-50
10	-"-	Extra conducting black, type II	-33	30-60
	Butyl grafted polyethylene	-"-	-25	7-10
15	Ethylene butyl acrylate copolymer	Acetylene carbon black	-35	40-50
	-"-	P carbon black	-38	5-10
	Ethylene propene rubber	Extra conducting carbon black	-35	200-400

In the joint assembly illustrated end portions of the electrical insulation 5, 7, 9 and 11 have been removed to expose end portions of the conducting means 4, 6, 8 and 10, respectively. In Figure 1, the intermediate and outer layers of each electrical insulation "band" has been cut away. For each electrical insulation "band", the inner layer of semiconducting material is covered by the surrounding intermediate insulating layer and cannot be seen.

After the cable ends have been prepared to expose the conducting means, the inner conducting means 4 and 8 are connected together, e.g. by soldering, clamping and/or crimping, at joint 15. Further electrical insulation 20 is then applied over the joint 15, conducting means 4 and 8 and insulation 5 and 9. Next the outer conducting means 6 and 10 are connected together, e.g. by soldering, clamping and/or crimping, at joint 25. Further electrical insulation 30 is then applied over the joint 25, conducting means 6 and 10 and insulation 7 and 11. The electrical insulation 20

(30) has an inner layer 20a (30a) of semiconducting material, an intermediate layer 20b (30b) of insulating material and an outer layer of semiconducting material 20c (30c). These insulation layers are shown only schematically and can be formed and/or applied in a number of different ways as discussed below.

One method of forming the insulation 20 (30) is to extrude the layers 20a-c (30a-c) in position. The extruded layers may be formed of similar materials to the layers of 10 the electrical insulation 5, 7, 9 and 11 described above.

It is also possible to build up the electrical insulation layers 20a-c (30a-c) from tightly wound, overlapping layers of tape, film or sheet-like material. Both the semiconducting layers 20a, 20c (30a, 30c) and the 15 electrically insulating layer 20b (30b) can be formed in this manner. The electrical insulation can be made of all-synthetic films with the inner and outer semiconducting layers made of polymeric thin film of, for example, PP, PET, LDPE or HDPE with embedded conducting particles, such as 20 carbon black or metallic particles, and with the intermediate insulating layer between the semiconducting layers. The layers, after winding to the desired thickness may also be vulcanised in situ by the application of heat. Polyethylene based tapes including appropriate 25 semiconducting or insulating material may be consolidated around the joined conducting means by heat shrinking.

For the lapped concept a sufficiently thin film will have butt gaps which are sufficiently small such that the partial discharge inception field strength, according to 30 Paschen's law, exceeds the operational field strength thus rendering liquid impregnation unnecessary. A dry, wound multilayer thin film insulation has also good thermal properties.

Another example of suitable electrical insulation 20 35 (30) is insulation similar to that of a conventional

cellulose based cable, where a thin cellulose based or synthetic paper or non-woven material is lap wound around a conductor. In this case the inner and outer semiconducting layers, on either side of the intermediate insulating layer, 5 can be made of cellulose paper or non-woven material made from fibres of insulating material and with conducting particles embedded. The insulating layer can be made from the same base material or another material can be used.

Another example of suitable electrical insulation is 10 obtained by combining film and fibrous insulating material, either as a laminate or as co-lapped. An example of such insulation is the commercially available so-called paper polypropylene laminate, PPLP, but several other combinations of film and fibrous parts are possible. In these 15 insulations, various impregnations such as mineral oil or liquid nitrogen can be used.

A yet further electrical insulation comprises preformed slip-on sleeves. The electrical insulation may be built up of separate sleeves forming the individual 20 semiconducting and insulating layers. Preferably, however, the individual semiconducting and insulating layers are formed in an integral, preformed sleeve. Certain types of sleeve can be made of elastic material and are prefabricated with an undersized diameter. The sleeve is then expanded in 25 diameter, e.g. with a simple tool, and slipped over the jointed conducting means and the tool removed to allow the sleeve to elastically contract onto the joint. Alternatively, certain types of sleeve may be shrunk after fitting by the application of heat.

30 Figure 1 is only schematic. However it should be appreciated that there should be no gaps between the various layers of each insulation band 5, 7, 9 and 11. The surrounding insulation "bands" can be spaced from the underlying conducting means although there should be 35 electrical contact along the length of the insulation, e.g. at spaced apart intervals, between the semiconducting inner

layer 20a, 30a and the underlying conducting means. Such electrical contact may be provided by spring contact means 35 (see Figure 2) between the conducting means and a the surrounding adjacent semiconducting layer 20a or 30a. The 5 spring contact means 35 comprises a number of curved or angled metallic prongs or fingers 36 held together by a circumferential band 37. Spring pressure ensures that the prongs contact both the conducting means and the surrounding semiconducting layer.

10 In the cable joint assembly 1 each cable 2, 3 has an inner conducting means 4, 8 and a single surrounding coaxial outer conducting means 6, 10. In other embodiments of the invention, each cable may have more than one, e.g. two or more, coaxial conducting means surrounding the inner 15 conducting means. With such cables, there will be a separate "band" of electrical insulation surrounding each conducting means. Although not shown, the outermost semiconducting layer 7a, 11a will, in use, be maintained at a controlled potential, preferably earth potential, at 20 spaced apart regions along its length.

A cable joint assembly according to the invention may be adapted to join together cooled cables, e.g. cooled superconducting cables. With cooled cables, cooling tubes of different cables are conveniently joined together at the 25 joint assembly by means of slip-on tubular sections covering abutting ends of cooling tubes. Plastic tubular sections may be glued to the cooling tube ends or may be vulcanised or heat shrunk in position. The mechanical joint of a metallic cooling tube may be strengthened with 30 circumferential clamps and/or by soldering/brazing the connection.

In Figure 3 there is shown schematically part of one cooled power cable 40 which can be joined to a similar cooled power cable (not shown) in a joint assembly according 35 to the invention. The cable 40 is similar in many respects to the cables 2, 3 described above and, where possible, the

same reference numerals have been used to identify parts similar to those of cable 2.

In Figure 3, the cable 40 has a stranded inner conductor 4 surrounded, and contacted, by a band 5 of electrical insulation comprising inner and outer preformed, e.g. moulded, layers 5a' and 5a, respectively, of semiconducting material and an intermediate layer 5b of insulating material. The inner and outer layers 5a' and 5a have elongate axial channels 41 and 42 formed in their respective inner and outer surfaces. An outer stranded conductor 6 is wound around, in contact with, the tubular outer layer 5a. The inner conductor 4 and inwardly opening channels 41 in the layer 5a', and the outer conductor 6 and outwardly opening channels 42 in the layer 5a, define axial cooling ducts for cooling fluid. A further band 7 of insulation is positioned around the conductor 6. The insulation band 7 comprises inner and outer layers 7a' and 7a of semiconducting material and an intermediate insulating layer 7b. The stranded inner conductor 4 may fill the core of the cable. Alternatively, however, a cooling channel and/or flexible support tube may be provided at the centre of the cable.

In order to join two such cables 40 together, a similar procedure is adopted to that described for the joint assembly of Figure 1. However, a separate procedure has to be adopted to join the channelled semiconducting layers 5a' and 5a. In particular, the layers 5a of the two cables are joined, e.g. adhesively, by a surrounding rigid tubular part which may be superconducting. The layers 20b and 20c of the joint assembly are then positioned over the tubular part as described previously. Another rigid, and possibly superconducting, tubular part is then positioned over, and adhesively joined to, e.g adhesively to, the end portions of the channelled layers 5a to be joined together. The outer conducting means are then joined and the outer insulation layers applied as previously described for the embodiment of Figure 1.

The cable 40 may be modified by replacing the stranded conductors 4 and 6 with superconducting conductors. For example, superconducting means could be provided by high temperature superconducting ("HTSC") tape or wire wound around a metallic tubular support which may have a degree of flexibility. The wire suitably comprises an HTSC core included inside a copper, copper alloy, silver or silver alloy strand. Typical of such HTSC wires or threads are silver-sheathed BSCCO-2212 or BSCCO-2223. In order to join together two such HTSC wires, the ends of the wires may be overlapped as shown in Figure 4 and the conductive outer layers 45 soldered or otherwise joined together. The length of the overlap should be sufficient to provide a good electrical contact of the outer layers. Since the inner cores 44 are in electrical contact with their conductive outer layers 45, the latter act as "bridges" for electrically connecting the inner cores together. The metallic support tubes on which the HTSC tape or wire is wound are mechanically joined together, e.g. by welding.

The electrical insulation used in a joint assembly according to the invention is intended to be able to handle very high voltages and the consequent electric and thermal loads which may arise at these voltages. By way of example, a power induction device incorporating a joint assembly according to the invention may comprise a power transformer having a rated power of from a few hundred kVA up to more than 1000 MVA and with a rated voltage ranging from 3-4 kV up to very high transmission voltages of 400-800 kV. At high operating voltages, partial discharges, or PD, constitute a serious problem for known insulation systems of power induction devices. If cavities or pores are present in the insulation, internal corona discharge may arise whereby the insulating material is gradually degraded eventually leading to breakdown of the insulation. The electric load on the electrical insulation of a cable of a joint assembly according to the present invention is reduced by ensuring that the innermost semiconducting layer of the insulation is at substantially the same electric potential

as the inner conducting means, that the outermost semiconducting layer is at a controlled, e.g. earth, potential and that the or each intermediate semiconducting is at the potential of the conducting means that it is in contact with. Thus the electric field is distributed substantially uniformly across the different intermediate layers. Furthermore, by having materials with similar thermal properties and with few defects in the layers of the insulating material, the possibility of PD is reduced at a given operating voltages. A joint of a power induction device can thus be designed to withstand very high operating voltages, typically up to 800 kV or higher.

Power induction devices incorporating power cable joint assemblies according to the invention may comprise, for example, motors, generator, transformers, energy storage devices, such as SMES devices, or fault current limiters.

CLAIMS

1. A cable joint assembly (1) comprising:

5 first and second cables (2; 3) joined end to end, each cable having at least two coaxially arranged electrically conducting means (4,6; 8,10) and, positioned around each electrically conducting means of each cable, solid electrically insulating means (5,7; 9,11), each solid electrically insulating means comprising inner and outer layers (5a,7a; 9a,11a) of semiconducting material and, between said inner and outer layers, an intermediate layer (5b,7b; 9b,11b) of electrically insulating material;

10 15 the solid electrically insulating means being removed from each joined cable end to expose one end of the electrically conducting means of each cable;

the said one end of each of the conducting means of one of the cables being joined at a separate joint (15, 25) to a corresponding one end of each of the conducting means of the other cable; and

20 additional electrical insulation means (20, 30) surrounding each pair of joined together conducting means at said joints (8, 15).

25 2. A cable joint assembly according to claim 1, characterised in that each of said first and second cables (2,3) has three coaxially arranged electrically conducting means.

30 3. A cable joint assembly according to claim 1 or 2, characterised in that each additional electrical insulation means (20, 30) comprises an inner first layer (20a, 30a) of semiconducting material, an outer second layer (20c, 30c) of semiconducting material and, between said

first and second layers, an intermediate third layer (20b, 30b) of electrically insulating material.

4. A cable joint assembly according to claim 3, characterised in that each of the first, second and third 5 layers of each additional electrical insulation comprises a separate, prefabricated sleeve.

5. A cable joint assembly according to claim 3, characterised in that each of the first, second and third layers of each additional electrical insulation are formed 10 as an integral, prefabricated sleeve.

6. A cable joint assembly according to claim 4 or 5, characterised in that each sleeve is made of elastic material.

7. A cable joint assembly according to claim 4 or 15 5, characterised in that each sleeve is heat shrunk in position.

8. A cable joint assembly according to claim 3, characterised in that each of the first, second and third layers of each additional electrical insulation comprises 20 tape wound around the associated joint.

9. A cable joint assembly according to claim 8, characterised in that each of said third layers comprises tape of insulating material.

10. A cable joint assembly according to claim 8 or 25 9, characterised in that each of said first and second layers comprises tape of semiconducting material.

11. A cable joint assembly according to claim 8, characterised in that said tape comprises cross-linked tape.

12. A cable joint assembly according to any one of 30 the preceding claims, characterised in that said electrical

insulation means comprises low or high density polyethylene (LDPE or HDPE), polybutylene (PB), polymethylpentene (PMP), ethylene (ethyl) acrylate polymer, a fluoropolymer, cross-linked materials or rubber insulation.

5        13. A cable joint assembly according to claim 12, characterised in that said cross-linked materials comprise cross-linked polyethylene (XLPE).

10      14. A cable joint assembly according to claim 12, characterised in that said rubber insulation comprises ethylene propylene rubber (EPR) or silicone rubber.

15      15. A cable joint assembly according to any one of the preceding claims, characterised in that each of said conducting means comprises superconducting means.

16. A cable joint assembly according to claim 15, characterised in that each of said superconducting means has cooling means associated therewith.

17. A cable joint assembly according to claim 15 or 16, characterised in that said superconducting means comprises elongate superconducting material helically wound around a support tube.

18. A cable joint assembly according to claim 17, characterised in that support tubes of the two cables are mechanically joined, e.g. welded, together.

19. A power induction device including at least one cable joint assembly according to any one of the preceding claims.

20. A power induction device according to claim 19, characterised in that it is designed for high voltage, suitably in excess of 10 kV, in particular in excess of 36 kV, and preferably more than 72.5 kV up to very high transmission voltages, such as 400 kV to 800 kV or higher.

21. A power induction device according to claim 19 or 20, characterised in that it is designed for a power range in excess of 0.5 MVA, preferably in excess of 30 MVA and up to 1000 MVA.

5        22. A method of joining together end to end first  
and second cables, each cable having at least two coaxially  
arranged electrically conducting means and, positioned  
around each electrically conducting means of each cable,  
solid electrically insulating means, each solid electrically  
10      insulating means comprising inner and outer layers of  
semiconducting material and, between said inner and outer  
layers, an intermediate layer of electrically insulating  
material, the method comprising joining exposed ends of the  
conducting means of one of the cables to corresponding  
15      exposed ends of the conducting means of the other cable and  
surrounding each pair of joined together conducting means  
with additional electrical insulation means.

23. A method according to claim 22, characterised in  
that, prior to the joining together of the conducting means,  
the ends of the two cables to be joined are prepared so that  
the solid electrically insulating means is removed to reveal  
the electrically conducting means of each cable.

24. A method according to claim 22 or 23,  
characterised in that each additional electrical insulation  
means comprises an inner layer of semiconducting material,  
a surrounding layer of electrically insulating material and  
a surrounding outer layer of semiconducting material, and in  
that said layers are applied successively during the  
formation of each electrical insulation means.

30 25. A method according to claim 24, characterised in  
that the said layers are applied as prefabricated sleeves.

26. A method according to claim 22 or 23, characterised in that each additional electrical insulation means comprises an integral preformed sleeve having an inner

layer of semiconducting material, a surrounding layer of electrically insulating material and a surrounding outer layer of semiconducting material.

27. A method according to claim 25 or 26,  
5 characterised in that the said sleeves are made of elastic material and in that each sleeve is elastically expanded during application before being allowed to contract into its final joint position.

28. A method according to claim 24, characterised in  
10 that each of said layers is formed by winding tape in at least partly overlapping layers.

29. A method according to claim 28, characterised in  
that the tape comprises a cross-linkable or cross-linked polymeric material.

15 30. A method according to claim 29, characterised in  
that the polymeric tape contains a cross-linking agent which is cross-linked by the application of heat and pressure after the tape has been wrapped around the joint.



21

Application No: GB 9912615.3  
Claims searched: 1-30

Examiner: Brendan Churchill  
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**Patents Act 1977**  
**Search Report under Section 17**

**Databases searched:**

UK Patent Office collections, including GB, EP, WO & US patent specifications, in:

UK Cl (Ed.R): H1A (AJS)  
H2E (EEMC, EFBA, EFCM, EFCP, EFCQ)

Int Cl (Ed.7): H01B, H01R, H02G

Other: Online: EPODOC, JAPIO, WPI

**Documents considered to be relevant:**

Category	Identity of document and relevant passage	Relevant to claims
A	GB 739962 (Standard Telephones and Cables) Particularly figure 1	1,3,22
A	EP 0469155 A1 (Furukawa Electric)	1,3,22
A	FR 2481531 A (Bonicel & Duret)	1,3,22
A	US 3787607 (Teleprompter)	1,3,22

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|---|--|
| X Document indicating lack of novelty or inventive step   | A Document indicating technological background and/or state of the art   |
| Y Document indicating lack of inventive step if combined with one or more other documents of same category. | P Document published on or after the declared priority date but before the filing date of this invention.          |
| & Member of the same patent family  | E Patent document published on or after, but with priority date earlier than, the filing date of this application. |